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PRINCIPLES OF PHYSICAL AND BIOLOGICAL SCIENCE FOUND IN EIGHT TEXTBOOKS OF GENERAL SCIENCE FOR GRADE EIGHT

by

Renato E. Leonelli

A thesis submitted to the School of Education, Boston University, in partial fulfillment of the requirements for the Degree of Master of Education

Boston, Massachusetts
April, 1947

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ACKNOWLEDGMENT

A pleasant part of conducting an investigation of this nature is the opportunity afforded the investigator to express his appreciation to all those who have assisted him in carrying it to a successful conclusion. Valuable suggestions and criticisms were furnished by the group of fellow teachers who composed the Seminar in Science Education, Boston University, 1946-1947, of which the investigator was a member. Grateful acknowledgment is especially made to Professor Vaden Miles of the School of Education for his invaluable help in the preparation of this work. Largely through his encouragement was the study undertaken. He gave many practical suggestions and valuable hints on the method of carrying on the work. Without his constant sympathetic interest and support, this study could not have been completed.

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CHAPTER I

INTRODUCTION

The realization that the world of the future will depend to a marked degree upon channeling the knowledge and applications of basic scientific principles into areas for the advancement of civilization was never more forcefully brought home to mankind than it has been through events and discoveries of recent years. Down through the ages, man's dependence on science has increased with every improvement in the methods of travel, work, and living itself. Gas warfare, jet propulsion, V-bombs, and long-range bombing attacks have recently had man at the mercy of science. Not until atomic bombs shattered Hiroshima and Nagasaki and blasted civilization into a new era did man finally realize his complete dependence on science. Man now senses the importance of these events to every living being for generations to come. Hence, there is a renewed interest in science and in the applications of its basic principles. From this awakening, a more active participation in the field of science can be expected.

In 1932, after Dr. Guy Montrose Whipple encountered difficulty in trying to interest the Council of the American Association for the Advancement of Science

CHAPTER I

INTRODUCTION

in the production of a textbook in the field of the teaching of science, the National Society for the Study of Education issued A Program for Teaching Science[1] as Part I of its Thirty-First Yearbook. This Yearbook[2] placed heavy stress upon the understanding of generalizations and principles. In order to satisfy one of the general aims of education--that of life enrichment through the ability to participate in our democratic order--experiences must, according to the Yearbook Committee, be provided in the classroom. It was postulated that these experiences could in "large part be developed from the understanding of principles and generalizations that ramify into human experiences."[3] Moreover, it was believed that a complete and thorough understanding of these principles should permit individual solution of problems which students will encounter. The school can, therefore, contribute "to life enrichment if its activities are of the kind from which ideas may be developed and if the ideas may in turn be associated into principles and generalizations that are interwoven into human experience."[4]

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[1] A Program for Teaching Science, Thirty-First Yearbook of the National Society for the Study of Education, Part I, Bloomington, Illinois: Public School Publishing Company, 1932.

[2] Ibid., p. 42.

[3] Ibid., p. 42.

[4] Ibid., p. 42.

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Part I, Bloomington, Illinois: Public School Publishing
Company, 1932.

[2] Ibid., p. 43.

[3] Ibid., p. 42.

[4] Ibid., p. 42.

According to the Progressive Education Association's Science in General Education, the student "should be able to develop the understandings, skills, and attitudes necessary for the maintenance of good physical and mental health. He should be aided in developing a sense of the growth and effectiveness of knowledge through study of the major scientific ideas, their influence on thought and conduct and on the conditions under which men live together, and their bearings upon man's conception of his place in the universe."[5]

All of this can be accomplished by a study of understandings which definitely have a central place in education. The Association uses the term generalizations to represent understandings.[6] Science instructors will have accomplished effective teaching only when an individual is able to understand a generalization in the light of "a group of relationships not previously sensed and so brings about a reorganization of his behavior."[7]

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[5]Progressive Education Association, Commission on Secondary School Curriculum, Science in General Education, p. 28. New York: D. Appleton-Century Company, 1938.

[6]Ibid., p. 61.

[7]Ibid., p. 55.

Downing[8] stated that if one is to lead pupils into healthful ways of living, he must give them an understanding of the important principles or laws of health. He further stated, that if a pupil is to become "a worthy member of the home, he must understand the principles of heredity, of home sanitation, etc., and must be sufficiently skillful in thinking to apply successfully such principles to the specific problems he must face."

SURVEY OF RESEARCH STUDIES ON PRINCIPLES AS OBJECTIVES OF INSTRUCTION IN SCIENCE TEACHING

At least five higher institutions of learning have worked or are currently working (1947) on scientific principles and the importance of such principles to the teaching of science. These studies, according to Martin,[9] are carried on independently at three schools: namely, the University of Chicago, under the direction of Elliot R. Downing (deceased); Columbia University, under the guidance of S. Ralph Powers and Gerald S. Craig; and the University of Michigan, under the leadership of Francis D. Curtis. More recently, further studies dealing with scientific principles are being conducted at New York University,

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[8]Elliot Rowland Downing, An Introduction to the Teaching of Science, p. 6. Chicago: University of Chicago Press, 1934.

[9]W. Edgar Martin, "A Chronological Survey of Research Studies on Principles," Science Education, XXIX (February, 1945), 45-52.

under the guidance of Charles J. Pieper and Martin L. Robertson, and at Boston University, with Vaden Miles as director.

In a study conducted in 1927, Craig[10] maintained that "certain objectives that are selected for a course of study in elementary school science should conform to those factors, principles, generalizations and hypothesis of science which are essential to the interpretation of common natural phenomena of the environments of man."

Heinemann[11] in 1927 made a study of twenty general science textbooks, in order to discover how much importance was accorded principles. A principle was defined as "a statement of relationship between two or more facts."[12] The books selected were those printed between 1915 and 1925. One book, published in 1917 and employing about fifty percent of all the principles found in the textbooks, contained forty-five principles. In all "ninety-three principles and over two-thousand applications to principles were found..."[13] According to Heinemann, "the results of this study would indicate that

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[10]Gerald S. Craig, Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School, Teachers College Contribution to Education, No. 276, pp. 56-57. New York: Teachers College, Columbia University, 1927.

[11]Ailsie M. Heinemann, "A Study of General Science Textbooks," General Science Quarterly, XIII (November, 1928), 11-25.

[12]Ibid., p. 11.

[13]Ibid., p. 22.

a book built on principles is yet to be written. Such a book would be in accord with the definition of a science, and were it enriched with applications to life situations it might meet a real need of the General Science teacher."[14]

Martin[15] stated that "in 1931, Wilbur under the direction of Curtis at the University of Michigan made an investigation to determine the scientific principles contained in textbooks of general science published between 1924 and 1931. In this study the criteria for the determination of a principle were formulated by six graduate students in a Seminar in Problems in the Teaching of Science."

Wilbur's definition of a principle and the criteria he used for determining whether a statement was or was not a principle were stated by Martin[16] as follows:

A principle of science is a comprehensive generalization which:

Is stated positively and definitely.
Is true but with rare exceptions within the limitations set up by the statement.
Clearly states or implies a dynamic process or interaction.
Is demonstrable experimentally.
Is clearly not a part of a larger principle which can be definitely stated.

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[14] Ibid., p. 23.
[15] Martin, op. cit., pp. 45-52.
[16] Ibid., p. 46.

> Is not merely a definition or description.
> Has wide application in the natural environment and is not ruled out by any of the preceding criteria.

Fourteen general science textbooks used in the ninth grade were analyzed by Wilbur.[17] The statements in the texts which satisfied the criteria given above were selected. "The principles were tabulated and submitted to subject matter specialists in biology, chemistry, geology, and physics for validation in terms of the criteria and for revision of the statements which were inaccurately or unsatisfactorily stated. The list of 170 principles was then submitted to ten teachers of general science who were asked to designate these principles which were necessary, desirable or undesirable in a general science course." The findings of the study were that "'of the 170 different principles of science from all 14 textbooks, but 18 were given, even in part, in principle form, in more than half of the textbooks analyzed...of these 18 principles

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[17] Oliver B. Wilbur, A Study of the Principles of Science Contained in General Science Textbooks Published Since the Beginning of the Year 1924. Unpublished Master's thesis, University of Michigan, 1931. See W. Edgar Martin, "A Chronological Survey of Research Studies on Principles As Objectives of Instruction in Science," Science Education, XXIX (February, 1945), p. 47.

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[1] Oliver B. Wilbur, A Study of the Principles of Science Contained in General Science Textbooks Published Since the Beginning of the Year 1924. Unpublished Master's thesis, University of Michigan, 1931. See W. Hagar Martin, "A Chronological Survey of Research Studies on Principles As Objective of Instruction in Science," Science Education, XXIX (February, 1945), p. 47.

only five were among the principles...which were regarded as necessary by the ten instructors who evaluated them,' while five principles regarded as necessary by all the instructors were included in fewer than four of the fourteen textbooks analyzed."[18]

Downing[19] has done extensive work in analyzing writings dealing specifically with scientific principles and their application. He deplores the fact that the science textbooks in most of the secondary schools devote a very small space to a clarification of the principles or to the application of these principles to actual problems which the students will face. He states that "scientific facts, unless organized to demonstrate or elucidate principles, are relatively useless. They do not function in problem solving; they are soon forgotten...In so far as they (textbooks) do deal with principles, the ones presented are often not those of most importance in solving the problems that arise in the life of the average person."[20]

Robertson[21] in 1934 investigated ten studies

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[18] Ibid., p. 47.

[19] Downing, op. cit., pp. 37-51.

[20] Ibid., pp. 49-50.

[21] Martin L. Robertson, A Basis for the Selection of Course Content in Elementary Science. Unpublished Doctor's dissertation, University of Michigan, 1934. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 3-19.

dealing with scientific principles. From these sources, he selected major and minor scientific principles. The following criteria[22] of a principle of science were used as a basis of selection of principles:

To be a principle, a statement:
Must be a comprehensive generalization.
It must be true without exception within the limitations specifically stated.
It must be a clear statement of a process or an interaction.
It must be capable of illustration so as to gain conviction.
It must not be part of a larger principle.
It must not be a definition.
It must not deal with a specific substance or variety, or with a limited group of substances of species.

A jury, consisting of the investigator and three representatives of the Science Department of the University of Michigan High School, compared the principles that were found in one source with the criteria listed above. Those principles which did not conform to the criteria were discarded. In a few instances, principles were reworded so as to meet the standards set up. Those principles that satisfied all of the requirements of the criteria were returned. Those statements which were deemed to be doubtful were then analyzed by six specialists in the science field; two zoologists, two chemists, a physicist and a geologist. Each statement which

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[22] Ibid., pp. 4-5.

appeared to be untrue was discarded or reworded so that it could be classed as a correctly stated principle. The final list of principles and subsidiary principles totaled 243. These principles were then submitted to twenty supervisors and professors of the teaching of elementary science and were rated on a five-point scale. On the scale, 1 was the lowest rating for suitability for teaching in Grades I to VI, inclusive, and 5 was the highest. All those principles averaging 8.0 or more were deemed suitable for the teaching of science. From this rating, a final list was prepared. This list reduced the total to 113 principles. Robertson[23] also found that "There is a wide range of opinion among these elementary science experts with respect to the suitability of the various principles." and that "there is a noticeable lack of uniformity among investigators with respect to the statement of principles."

Pruitt[24] in 1935 conducted research to determine

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[23] Ibid., p. 6.

[24] Clarence Martin Pruitt, An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry. Doctor's dissertation, Teachers College, Columbia University, 1935. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 153-163.

the concepts and generalizations in chemistry which would be of definite aid to man in relation to his environment. An analysis was made of: three examinations; over 50,000 pages of material in five sociology books; a year's issue of The Atlantic Monthly, The Forum, and Harpers Magazine; a year's issue of eight newspapers; twelve issues each of Popular Science Monthly, Scientific American, and Science Newsletter; nine issues of Scientific Monthly; and 55 textbooks covering the various science subjects. From this analysis, concepts and generalizations were selected which conformed to the following criteria:[25]

A generalization shall be as simple, comprehensive, and definitely stated as possible.
A generalization must be a statement of some fundamental process, or constant mode of behavior or property relating to natural phenomena.
A generalization must be true without exceptions within the limitations made in the statement.
A generalization must be a statement capable of demonstration.
A generalization must not be subordinate to a larger generalization.
A generalization must not deal with specific or limited groups of substances.
A generalization must not be a definition.

One hundred thirty-five generalizations were selected as meeting these criteria.

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[25]Ibid., p. 156.

Wise[26] conducted an extensive investigation in 1941 to determine those principles of physical science which are most important for general education. The criteria which he used for this investigation were very similar to those employed by Arnold, Pruitt and Robertson. Following are the criteria[27] used by Wise:

> A principle is defined in terms of four criteria:
> A. To be a principle, a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.
> B. It must be true without exception within limitations specifically stated.
> C. It must be capable of illustration.
> D. It must not be a definition.

With the above criteria as a standard, 252 principles were found. These principles were classified into the following fields: physics, including astronomy and meteorology, 165; chemistry 68; and geology 19. Contributing studies resulted in twenty additional principles which also satisfied the criteria thus making a total of 272 principles. These were then submitted to specialists in the fields of physics, chemistry, and geology. Each of the specialists submitted written recommendations to the investigator for

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[26]Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished Doctor's dissertation, University of Michigan, 1941. See Science Education, XXV (December, 1941), 371-9; XXVI (January, 1942), 8-12; XXVII (February, 1943), 36-40; XXVII (September-October, 1943), 67-76.

[27]Ibid., p. 371.

the restatement of certain of the principles "in accordance with the criterion pertaining to the accuracy of the statement."[28] Of the final defensible list of 272 principles of physical science, 264 were arranged in the relative order of importance for general education grades I-XIV, inclusive.

In an analysis of textbooks of science for the elementary grades, Reek[29] in 1943 found that the ideas propounded by the Thirty-First Yearbook had not taken effect upon the authors and publishers of the textbooks.

In 1944, an investigation was conducted by Martin[30] which closely paralleled the work performed by Wise. Martin, however, determined the principles of biological science of importance for general education.

The criteria[31] used by Martin are as follows:

(1) It must be a comprehensive generalization which resumes the widest possible range of facts within the domain of facts with which it is directly concerned. The facts resumed in the generalization must denote:

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[28] Ibid., p. 575.

[29] Doris Lucille Reek, A Study of the Principles of Science Found in Four Series of Textbooks of Elementary Science. Unpublished Master's thesis, University of Michigan, 1943.

[30] W. Edgar Martin, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education, XXIX (February, 1945), 45-52; XXIX (March, 1945), 100-5; XXIX (April-May, 1945), 152-65.

[31] Ibid., p. 50.

a. Objects and/or events and the relations between them.
b. Properties.

(2) It must be scientifically true. To satisfy this criterion:
a. It must be verifiable; i.e., it must be stated so that it suggests, directly or indirectly, a definite observation or experiment whereby its truth value can be tested or verified.
b. It must be consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data (facts) relevant to it.

The material analyzed consisted of three junior college textbooks in the natural sciences, three biology textbooks of the secondary-school level, scientific principles in the reports of five research studies, and "a survey series of the biological sciences prepared for the general reader."[32]

The statements obtained were then submitted to three specialists in the science field, and the generalizations were evaluated "each in terms of two criteria: (1) Is the statement a generalization of the biological sciences? (2) Is it a principle?"[33]

The statements which were found to satisfy both criteria were classified as major principles; those which satisfied only the first criterion were considered minor

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[32] Ibid., p. 50.
[33] Ibid., p. 50.

principles. The investigator then referred all the major principles to three subject-matter specialists. These specialists refined the statements and determined the veracity of the generalizations.

Martin[34] also, "analyzed the materials found in two years consecutive issues of two specialized magazines, Hygeia, and Nature Magazines, of two non-specialized magazines, Life and Readers Digest, and in a random sampling of twenty-four issues of three selected newspapers for the period from 1929 to 1943. The issues were read and analyzed for materials for the understanding of which a comprehension of a principle, or principles from the major or minor lists might be considered necessary. For each statement, or statements from any one article which were assigned to a principle in the lists, the principle was arbitrarily assigned a frequency of 1. A total of 2620 statements or articles from the magazine and newspaper materials analyzed, was assigned to 222 of the 300 major principles and minor principles related to them."

Fleish[35] in 1945 conducted a study to "determine

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[34]W. Edgar Martin, "A Chronological Survey of Published Research Studies Relating to Biological Materials in Newspapers and Magazines," School Science and Mathematics, XLV (June, 1945), 543-550.

[35]Sylvia Fleish, The Formulation of the Science Principles That Should Become the Objectives of General Science Teaching in the Junior High School. Unpublished Master's thesis, Boston University, 1945.

principles. The investigator then referred all the major principles to three subject-matter specialists. These specialists refined the statements and determined the veracity of the generalizations.

Martin[24] also analyzed the materials found in two years consecutive issues of two specialized magazines, Hygeia, and Nature Magazine, of two non specialized magazines, Life and Readers Digest, and in a random sampling of twenty-four issues of three selected newspapers for the period from 1928 to 1940. The issues were read and analyzed for materials for the understanding of which a comprehension of a principle, or principles from the major or minor lists might be considered necessary. For each statement, or statements from any one article which were assigned to a principle in the lists, the principle was arbitrarily assigned a frequency of 1. A total of 3020 statements or articles from the magazine and newspaper materials analyzed, was assigned to 282 of the 300 major principles and minor principles related to them.*

Pielan[25] in 1943 conducted a study to determine

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[24] W. Edgar Martin, "A Chronological Survey of Published Research Studies Relating to Biological Materials in Newspapers and Magazines," School Science and Mathematics, XLV (June, 1945), 580-590.

[25] Sylvia Pielan, The Formulation of the Science Principles That Should Become the Objectives of General Science Teaching in the Junior High School. Unpublished Master's thesis, Boston University, 1943.

those science principles which should become the objectives of the general science course."[36] Through the use of a question box procedure, it was seen that sixty principles of general science were found to underlie the questions of interest to the students of the junior high school. A list of twenty general science generalizations were also established for the elementary school.

Jones[37] in 1946 analyzed seven ninth-grade general science textbooks for scientific principles. The books selected were those published after the publication of the Thirty-First Yearbook, specifically to determine whether or not the writers conformed to the policies of the Yearbook Committee.

The following criteria were used by Jones:[38]

A principle of science is a comprehensive generalization which
Is stated definitely, not inferred.
Is true but with rare exceptions within the limitations set by the statement.
Is a clear statement of a dynamic process or of an interaction.
Is not merely a definition or a description.
Is demonstrable experimentally.
Does not deal with specific substances or varieties.
Has meaning outside of the context.

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[36] Ibid., p. 1.

[37] Ruth V. Jones, A Study of the Principles of Science Found in Ninth-Grade Textbooks of General Science, Unpublished Master's thesis, University of Michigan, 1946.

[38] Ibid., p. 24.

In this study a list of 146 principles were selected. Jones concluded that there is little or no agreement as to the scientific principles that should be taught at the ninth-grade level.

Bergman[39] conducted a study with the purpose of developing a list of principles of entomology in the order of their relative significance for general education. The investigator analyzed 17 entomological textbooks, 140 articles, research studies publications, etc., and 30 reference books dealing with specific aspects of entomology. A total of 52 principles of entomology were determined.

These fifty-two principles were then compared with the biological principles determined through previous studies of other men in science, to determine whether the principles found in entomology were based upon, related to, or subordinate to the biological principles.

The results showed that the total of 52 (45 major and 7 minor) principles of entomology are subordinate to, related to, or correspond to a total of 45 (27 major and 18 minor) principles of biology. A concluding article by Bergman did not appear in the literature in time to be included here.

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[39]George J. Bergman, "A Determination of the Principles of Entomology of Significance in General Education," Science Education, XXXI (February, 1947), 23-32.

Blanchet,[40] using Wise's list of 272 principles of physical science, Martin's list of 300 biological principles and the criteria of a principle employed by them, respecively, employed defensible research techniques

> To determine the principles of science most suitable as goals for survey courses in the natural sciences at the junior-college level,
> To determine the extent of their inclusion in textbooks for use in survey courses,
> To obtain a list of informational items, in outline form, for these courses, and
> To survey student opinion concerning the relative values of topics studied in them.[41]

The principles of science most suitable as goals for survey courses in the natural sciences were determined "on the basis of the combined judgments of college teachers of science and of specialists in the teaching of sciences."[42]

It was necessary to develop criteria for selecting principles from textbooks in order "to determine the extent to which the principles of science most suitable as goals for survey courses in the natural sciences were included in textbooks published for use in these courses."[43] In selecting principles from textbooks, Blanchet[44] used the following criteria:

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[40]Waldo Emerson Blanchet, A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences. Unpublished Doctor's dissertation, University of Michigan, 1946.

[41]Ibid., p. 34.

[42]Ibid., p. 37.

[43]Ibid., p. 115.

[44]Ibid., p. 118.

[41]Ibid., p. 64.
[42]Ibid., p. 37.
[43]Ibid., p. 110.
[44]Ibid., p. 116.

A statement was considered to be that of a particular principle

1. If it expressed completely the idea embodied in the original statement of the principle.
2. If, though it did not state all of the elements of the principle, it was referred to by the author or authors as being the said principle.
3. If it unmistakably implied the principle and could be so reworded so that the principle was stated.
4. If, though it did not state the principle in full, it could be combined justifiably with another statement in the same paragraph or section, which together stated the principle or could be reworded to do so.

After formulating a composite outline of topics related to the physical sciences and a similar outline related to the biological sciences and having the defensibility of the position of each topic in the outline approved, Blanchet[45] employed three specialists in the teaching of science to check the defensibility of the assignment of a large sampling of the topics to principles on the basis that a discussion of a topic might reasonably be expected to include materials contributory to developing an understanding of a principle. "A total of 1171 assignments of physical topics was made to the [272] physical principles and 970 assignments of biological topics were made to the 300 principles of the biological sciences."[46]

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[45] Ibid., pp. 302-307; 340-416.

[46] Ibid., p. 307.

Keeslar's[47] investigation represents the only effort "to determine the extent to which certain selected instructional films in science contribute...to the realization of three major objectives of science education in the secondary schools. These three teaching objectives, in terms of which the film contents were analyzed, are:

I. To effect an understanding of scientific principles that will function in the everyday life and activities of the student.
II. To teach the elements of scientific method as skills to be employed in the solution of problems.
III. To develop the scientific attitudes."[48]

It was "considered that an expressed idea in a film makes a contribution to the understanding of a SCIENTIFIC PRINCIPLE if it seems reasonable to infer (that is, if there is defensible evidence to indicate) that the narrator of a sound film or the author of sub-titles in a silent film had a definite scientific principle in mind and was manifestly attempting to teach it."[49]

This principle must have photographic or narrated data to illustrate it and must satisfy at least one of the following conditions:

a. The expressed idea must be unmistakably a statement of a scientific principle, satisfying the criteria of a principle, or the narrator must designate it to be a principle. In the latter case, also, it must satisfy the criteria of a principle.

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[47]Oreon Keeslar, "Contributions of Instructional Films to the Teaching of High School Science," Science Education, XXX (March, 1946), 82-88.

[48]Ibid., p. 84.

[49]Ibid., p. 85.

b. The statement must be capable of being reworded so as to become a scientific principle, without loss of its essential idea.
c. The statement must employ a technical term or phrase which has direct reference to an accepted scientific principle, or which cannot be understood without an understanding of a scientific principle.

To be considered a scientific principle, a statement
Must be a generalization.
Must be a clear statement of a process or an interaction.
Must be capable of illustration so as to gain conviction.
Must not be a definition.
Must not deal with a specific substance or variety, or with a limited group of substances or species.

With respect to principles, Keeslar[50] concluded that "When the six films of the inspirational type, in which the theme or subject-matter tended to preclude the possibility of developing understandings of scientific principles, were disregarded, it was found that sixteen of the remaining eighteen films went beyond the mere presentation of scientific information. In addition to furnishing mere facts, these films summed up the facts with generalizations which met the criteria for a scientific principle. These generalizations occurred in frequencies ranging from one to thirteen, averaging about five and one-third principles per film."[51] He further concluded, however, that "The best available scientific

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[50]Oreon Keeslar, "Contributions of Instructional Films to the Teaching of High School Science," Science Education, XXX (April, 1946), 132-136.

[51]Ibid., p. 134.

films reveal no definite intention or attempt to teach scientific principles."[52] In fact, "nearly half (44.1 percent) of the contents of the twenty-four films served no unique or specialized functions and contributed to none of the three major objectives."[53]

REVIEW OF RESEARCH STUDIES PERTAINING TO RETENTION OF FACTS, SCIENTIFIC PRINCIPLES AND GENERALIZATIONS

Frutchey[54] conducted an investigation on the amount of material that was retained by students who had taken a high school course in Chemistry. "The five objectives of high school chemistry chosen for study were: the selection of chemical facts and principles; a knowledge of chemical terms; a knowledge of symbols, formulas, and valence; and the balancing of chemical equations."[55] All of the above objectives were translated in terms of the behavior of pupils and tests were prepared--five in all--to obtain evidence of each type of behavior.

The tests were given at the start of the high school course and repeated nine months later upon completion of the course. A basis was established by the differences of the scores attained. The difference represented a gain

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[52] Ibid., p. 134.
[53] Ibid., p. 134.
[54] F. P. Frutchey, "Retention in High School Chemistry," Educational Research Bulletin, Ohio State University, XVI (February 17, 1937), 34-37.
[55] Ibid., p. 35.

time proved no definite intention or attempt to teach scientific principles."[32] In fact, "nearly half (6 of 13 percent) of the contents of the twenty-four films served no unique or specialized functions and contributed to none of the three major objectives."[33]

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[32]Ibid., p. 134.
[33]Ibid., p. 136.
[34]P. Trutchey, "Retention in High School Chemistry," Educational Research Bulletin, Ohio State University, XXI (February 17, 1942), 64-67.
[35]Ibid., p. 65.

for each student. Exactly one year later the students were retested. The amount of retention was measured by the difference of the scores between the third test and the second test.

Results of this study show that after an absence of one year "in their application of facts and principles their retention was ninety-two percent of the gain they (the students) made during the course."[56]

Zeigler[57] tested two groups of students in order to measure fact retention on the high-school level. One group consisted of students that had studied general science three years previously and the second group consisted of students that had just completed the study of general science. Two hundred and twenty-five multiple choice items based on thirteen units were administered to the students. The findings showed that those students that had just completed the study of general science obtained a mean score of 72.7 on several of the units tested, while those students that had studied general science three years previously had a mean score of 52.5. The findings also pointed out that those

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[56] Ibid., p. 37.

[57] Robert T. Zeigler, "A Study of Fact Retention in General Science," Science Education, XXVI (February, 1942), 83-84.

principles which were encountered in every day life were retained to a greater extent than those principles which were not encountered in every day life.

Johnson[58] conducted an investigation with respect to retention of factual knowledge in the courses in elementary botany at the University of Minnesota. Tests administered to three groups following completion of a course "showed the following median percentage losses: 46.1 percent after three months; 74.1 percent after 15 months; and 76.1 percent after 27 months." "The rate of loss would, therefore, appear to be quite rapid during the three and fifteen months after completing the course, followed by a gradual decline afterwards."[59]

Tyler[60] conducted a study "to determine the relative retention by pupils of factual knowledge, ability to explain everyday happenings, and ability to generalize from facts."[61]

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[58]Palmer O. Johnson, "The Permanence of Learning in Elementary Botany," The Journal of Educational Psychology, XXI (January, 1930), 37-47. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, p. 305.

[59]Ibid., p. 305.

[60]Ralph W. Tyler, "What High-School Pupils Forget," Educational Research Bulletin, Ohio State University, IX (November 19, 1930), 490-492. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 304-306.

[61]Ibid., p. 304.

Sixty-eight students who had completed a course in general science were given a battery of three tests three months and twelve months after completing the course to determine their amount of retention. The findings show that "The greatest loss...was in [factual] information..., whereas there was little or no loss in the ability to explain everyday phenomena and the ability to generalize from given facts."[62]

Another investigation by Tyler[63] involving 82 students who studied elementary zoology at Ohio State University was made to determine the relative permanence of their learning. It was found that fifteen months after the students had completed their course they had forgotten as much as 77 percent of a type of factual knowledge, while for the same period of time their ability to apply scientific principles to solve new problem situations had increased.

Wert[64] tested students for three successive years immediately following the completion of a course in

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[62] Ibid., p. 306.

[63] Ralph W. Tyler, "Permanence of Learning," Journal of Higher Education, IV (April, 1933), 203-204. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 306-308.

[64] James E. Wert, "Twin Examination Assumptions," Journal of Higher Education, VIII (March, 1937), 136-140. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 310-312.

elementary zoology. He found a great loss in factual knowledge, the loss ability increasing with the passage of each year, contrasted to a marked increase with the passage of time in the ability of the students to apply principles in solving new problem situations.

SUMMARY OF RESEARCH STUDIES

The Thirty-First Yearbook and research studies emanating from the University of Michigan, University of Chicago, Boston University, Columbia University, University of Minnesota, New York University, and Ohio State University justify the development of a functional understanding of scientific principles as a major objective of the teaching of science.

Robertson, Martin, and Wise have made important contributions in the statement of scientific principles. Martin and Wise conducted their investigations ostensibly for grades I-XIV but actually on a junior-college level; Jones continued the work on the ninth-grade level. The criteria for a principle employed by these investigators appear to be reaching a standard pattern.

Frutchey, Zeigler, Johnson, Tyler, and Wert in their studies on retention have all shown conclusively that with the passage of time factual knowledge is increasingly

forgotten, but there is a marked increase in the ability of students to use scientific principles to solve new problem situations.

THE PROBLEM OF THIS INVESTIGATION

This investigation is an attempt to determine the principles of physical and biological science that are found in eight textbooks of general science for grade eight published or revised since 1935. The principles are to be determined by criteria established by the investigator.

STATEMENT OF THE PROBLEM

The problem of this investigation is to determine the principles of physical and biological science found in eight textbooks of general science for grade eight.

SCOPE AND LIMITATIONS OF THIS INVESTIGATION

This investigation is limited to an analysis of eight textbooks of general science written specifically for the eight-grade level. The textbooks analyzed are the second book of a three-book series in general science for the junior high school. All books must have been published or revised since 1935.

Only those principles will be selected that appear to the writer to conform to the criteria established for this investigation.

CHAPTER II

THE RESEARCH

RESTATEMENT OF THE PROBLEM

The problem of this investigation is to determine the principles of physical and biological science found in eight textbooks of general science for grade eight.

TECHNIQUES EMPLOYED

Selection of Textbooks for Analysis

A group of fifteen science teachers in a Seminar in Science Education at Boston University, 1946-47, adopted for the purpose of this investigation the following criteria as a basis for the selection of textbooks of general science to be analyzed for the inclusion of scientific principles. The textbooks must:

1. Be the second book of a three book series in general science for the junior high school and therefore be written specifically for the eight-grade level;
2. Be published by well-known publishing houses with sales in all regions of the United States;

CHAPTER II

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PROCEDURES EMPLOYED

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1. Be the second book of a three book series in general science for the junior high school and therefore be written specifically for the eight-grade level;

2. Be published by well-known publishing houses with sales in all regions of the United States;

3. Be available for use at the time the study is started;

4. Have been published or revised since 1935 thereby giving the authors and publishers sufficient time to incorporate in the textbooks the ideas set forth in the Thirty-First Yearbook; and

5. Have been written by men well known in the field of General Science.

Eight textbooks were found to satisfy the above five criteria. Following is a list of the eight textbooks so selected together with an assigned number by which each textbook is hereafter identified:

1. Science Problems, Book 2. Wilbur L. Beauchamp, John C. Mayfield, and Joe Young West, Chicago: Scott, Foresman and Company, 1939.

2. Science on the March, Book 2. John A. Clark, Frederick L. Fitzpatrick, and Edith Lillian Smith, Boston: Houghton Mifflin Company, 1943.

3. Our Environment, How We Adapt Ourselves to It, Harry A. Carpenter, George C. Wood and Paul E. Smith, Boston: Allyn and Bacon, 1943.

4. The Wonderworld of Science, Book Eight, Morris Meister, Ralph E. Keirstead and Lois M. Shoemaker, New York: Charles Scribner's Sons, 1944.

5. Science in Our Social Life, George W. Hunter and Walter G. Whitman, New York: American Book Company, 1935.

6. Enjoying Science, Victor C. Smith and Gilbert H. Trafton, Chicago: J. B. Lippincott Company, 1942.

7. Our World Changes, Samuel Ralph Powers, Elsie Flint Neuner, Herbert Bascom Bruner and John Hodgdon Bradley, Boston: Ginn and Company, 1946.

8. Understanding Our World, Franklin B. Carroll, Philadelphia: John C. Winston Company, 1939.

The major units of the textbooks selected for analysis are listed below:

Book 1.

Unit I	What is the Relationship of the Earth to other Heavenly Bodies?
Unit II	How is Force of Gravity Useful to Us?
Unit III	How does the Earth's Surface Change?
Unit IV	Why Do Some Things Rise and others Sink in Fluids?
Unit V	How Do We Use Energy?
Unit VI	How Do We Control Heat?
Unit VII	What Makes the Weather Change?
Unit VIII	How Do Our Bodies Work?
Unit IX	How Can You Help Your Body Fight Disease?

5. Science in Our Social Life, George W. Hunter and Walter C. Whitman, New York: American Book Company, 1950.

6. Applying Science, Victor C. Smith and Gilbert H. Trafton, Chicago: J. B. Lippincott Company, 1943.

7. Our World Changes, Samuel Ralph Powers, Hale Flint Benner, Herbert Bascom Bruner and John Hodgdon Bradley, Boston: Ginn and Company, 1946.

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Unit VIII — How Do Our Bodies Work?

Unit IX — How Can You Help Your Body Fight Disease?

Unit X How Does Life Continue on the Earth?

Unit XI How Does Man Take Care of the Plants and Animals He Uses?

Book 2.

Unit I Weather and Living Things

Unit II Health

Unit III Food

Unit IV Reproduction

Unit V Conservation

Unit VI Earth and Universe

Unit VII Plants and Animals

Unit VIII Energy and Engines

Unit IX Magnets and Electricity

Unit X Transportation and Communication

Book 3.

Unit I Weather

Unit II The Heavens

Unit III Water

Unit IV Community Sanitation

Unit V Farm and Garden

Unit VI Conservation

Book 4.

Unit I The Solar System

Unit II The Surface of the Earth

Unit III The Continuity of Life

Unit IV Energy for a World at Work

Unit V Energy for Transportation

Unit VI Energy for Communication

Book 5.

Unit I Control and Improvement of the Environment

Unit II Adaptations and Their Value

Unit III Proper Air Conditions Bring Comfort and Health

Unit IV A Citizen's Need of Water

Unit V How Heat is Used in Home and Community

Unit VI Light in Home and Community

Unit VII How We Use Electricity

Unit VIII Simple Machines in the Home

Unit IX The Sun, Time, and the Seasons

Unit X How the Earth's Surface Influences Man's Activities

Unit XI The Interdependence of Living Things

Unit XII Bacteria - Good and Bad

Unit XIII How the Community Protects Its Food Supply

Unit XIV How the Community Looks After the Health of Its Citizens

Unit IV Energy for a World at Work

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Unit XIV How the Community Looks After the Health of Its Citizens

Book 6.

Unit I	How Does Science Help Us Understand Our Surroundings?
Unit II	How Do Living Things Solve Their Problems?
Unit III	How Is Air Related to Changes in Energy?
Unit IV	How Do We Provide A Supply of Water?
Unit V	How Is Science Helpful in Buying and Selling?
Unit VI	What Bodies Are Near the Earth in Space?
Unit VII	How Does Clothing Keep Us Warm and Attractive?
Unit VIII	How Do We Obtain Help With Our Work?
Unit IX	How Can We Avoid Illness?
Unit X	What Changes Have Taken Place in the Earth's Surface?
Unit XI	How Can We Plant and Care for a Garden?
Unit XII	How Does Climate Affect Our Way of Living?

Book 7.

Unit I	The Changing Sky
Unit II	The Changing Air
Unit III	The Changing World of Life
Unit IV	The Changing Landscape
Unit V	Our Life in a Changing World
Unit VI	Conservation in a Changing World

Book 5.

Unit I	How Does Science Help Us Understand Our Surroundings?
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Unit II	The Changing Air
Unit III	The Changing World of Life
Unit IV	The Changing Landscape
Unit V	Our Life in a Changing World
Unit VI	Conservation in a Changing World

Book 8.

Unit I	How Living Things Fit the Earth
Unit II	Astronomy
Unit III	Weather and Climate
Unit IV	Water
Unit V	Some Plants and Animals of the House and Garden
Unit VI	Health
Unit VII	The Energy Around Us
Unit VIII	Heat in the World
Unit IX	Magnetism and Electrical Energy
Unit X	Making Work Easier
Unit XI	The Changing World

Upon examination of the subject-matter content it was readily seen that there was little or no agreement among the authors of different textbooks as to the subject matter to be taught the students of general science at the eighth-grade level.

Criteria for a Principle as Found in Textbooks of General Science for the Eighth Grade

A thorough study was first made of Wise's[1] list of 272 principles of physical science and

[1]Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished Doctor's dissertation, University of Michigan, 1941.

Book 3.

Unit I How Living Things Fit the Earth

Unit II Astronomy

Unit III Weather and Climate

Unit IV Water

Unit V Some Plants and Animals of the Home and Garden

Unit VI Health

Unit VII The Energy Around Us

Unit VIII Heat in the World

Unit IX Magnetism and Electrical Energy

Unit X Making Work Easier

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[1] Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished Doctor's dissertation, University of Michigan, 1924.

Martin's[2] list of 500 principles of biological science both of which were ostensibly for Grades I-XIV, inclusive, but were most frequently written in language on the junior-college level. The 146 principles of the physical and biological sciences found by Jones[3] in seven textbooks of ninth-grade general science were then considered. This was followed by the scanning of two of the eight textbooks used in the present investigation. This perusal revealed that many of the principles found by Jones[3] in the ninth-grade textbooks were also present at the eight-grade level.

The criteria upon which is based the determination of the principles in this investigation were then established. These criteria were tentatively arrived at by a study of the criteria of a principle from earlier investigations. Numerous discussions followed with members of a Seminar in Science Education conducted at Boston University. The criteria for a principle as found in textbooks of general science for the eighth grade and adopted by fifteen science teachers in a Seminar in Science Education, Boston University, 1946-47 are:

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[2]W. Edgar Martin, A Determination of the Principles of the Biological Sciences of Importance for General Education. Unpublished Doctor's dissertation, University of Michigan, 1944.

[3]Ruth V. Jones, A Study of the Principles of Science Found in Ninth-Grade Textbooks of General Science, Unpublished Master's thesis, University of Michigan, 1946.

are:

To be a principle for the eight-grade level of comprehension, a statement:

1. Must be a comprehensive generalization or a part of a comprehensive generalization.
2. Must be true without exception within the limitation specifically stated.
3. Must not be a definition.
4. Must be demonstrable experimentally.
5. Must be stated definitely and/or may be implied in the writings of the author.
6. Must not deal with specific substances.

In general, the above criteria agree with those used by Robertson,[4] Wise,[5] Jones,[6] and others.

Method of Analysis of Textbooks for Principles

A study was made of the various topics that were found in the table of contents of the eight textbooks used. Closely related topics were grouped together. The topics fell generally under the following headings: Astronomy; Sound; Light; Matter; Energy and Simple Machines; Weather and Climate; Magnetism and Electricity; Earth's Surface and Changes; Fire and Heat; Fluids; and Plants and Animals. A few chapters of some of the

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[4]Martin L. Robertson, A Basis for the Selection of Course Content in Elementary Science. Unpublished Doctor's dissertation, University of Michigan, 1934. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Co., Inc., 1939, pp. 3-19.

[5]Wise, op. cit., p. 18.

[6]Jones, op. cit., p. 24.

texts which could not be classified under any of the above headings were grouped under Miscellaneous.

The list of topics thus established was then used for the orderly analysis of the eight textbooks for principles, beginning with Astronomy in all eight textbooks and continuing until all eight topics were exhausted. The eight textbooks were then analyzed carefully for statements that satisfied the six criteria of a principle for the eighth-grade level of comprehension.

At first each principle was written on a 5" x 8" card; immediately below was designated the book in which the principle was found. Each book was given a number from 1 to 8. This method of recording the principles was soon discarded. Early in the investigation it became apparent that the cards needed would become too numerous to handle with facility.

In order to simplify the work, the principles were listed in table form on 8" x 11" paper. To the right of the principles were arranged eight columns, each numbered from 1 to 8, corresponding to the eight textbooks used for the investigation. A checkmark was placed opposite each principle under each textbook in which such a principle was found at least once. The wording of the principles found varied from one textbook to

another, but if the implication was present, each textbook was given credit for having the principle.

Coefficient of Reliability for the Selection of Principles from Textbooks

In order to determine the coefficient of reliability of the investigator's judgment in the selection of principles from textbooks, one month after the first analysis the investigator rechecked for principles, one hundred pages selected at random from one of the textbooks previously analyzed.

As a result of twice analyzing 100 pages from Book 8, it was found that 24 principles were common to both analyses. Two principles were determined upon the second analysis which were not determined during the first reading and also, two principles were determined in the first analysis which did not appear in the second analysis. Using the formula: coefficient of reliability equals $\frac{A}{A + B + C}$ where A is the number of principles common to both analyses; B is the number of principles found to appear only in the list resulting from the first analysis, and C is the number of principles found to appear only in the list of the second analysis, the following was obtained: coefficient of reliability equals $\frac{24}{28}$ or 0.86.

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book was given credit for having the principle.

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principles from textbooks, one month after the first
analysis the investigator rechecked for principles,
one hundred pages selected at random from one of the
textbooks previously analyzed.

As a result of twice analyzing 100 pages from
Book B, it was found that 84 principles were common to
both analyses. Two principles were determined upon
the second analysis which were not determined during
the first reading and also, two principles were deter-
mined in the first analysis which did not appear in the
second analysis. Using the formula: coefficient of
reliability equals $\frac{A}{A + B + C}$ where A is the number of
principles common to both analyses; B is the number of
principles found to appear only in the list resulting
from the first analysis, and C is the number of prin-
ciples found to appear only in the list of the second
analysis, the following was obtained: coefficient
of reliability equals $\frac{84}{84}$ or 1.00.

Validation of the Statement of the Principles

The statements of the principles used for this investigation were compared with the principles of science contained in the comprehensive lists formulated by Wise for the physical sciences and by Martin for the biological sciences to ascertain their inclusion in these comprehensive lists. Statements not so included were eliminated. The criteria for the determination of the principles for this investigation are in basic accord with those used by Wise and Martin.

All remaining statements of principles were submitted to a specialist in the teaching of science* who checked them for conformance to the criteria established and for technical accuracy of statement at the eighth-grade level of comprehension. Any statements of principles judged by him as not conforming to the criteria and which he could not reword to conform were deleted from the final list of principles. Furthermore, if the specialist thought that the language in a statement of a principle was not suitable for the eighth-grade level of comprehension, he reworded the principle to make it comprehensible at that level. Thus, the statements of the principles were properly validated.

*Vaden W. Miles, Assistant Professor of the Teaching of Science, Boston University.

Table I which follows shows the different principles or parts of principles which were found in eight eighth-grade textbooks of general science placed under the topics in which they appeared, and the total numbers of textbooks in which each principle was found.

TABLE I

THE NUMBERS OF EIGHTH-GRADE TEXTBOOKS OF GENERAL SCIENCE IN WHICH THE DESIGNATED PRINCIPLES OF PHYSICAL AND BIOLOGICAL SCIENCE WERE FOUND

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
ASTRONOMY									
*All the bodies in the solar system travel around the sun.	X	X	X	X		X	X	X	7
The force of gravity is greater on a larger and heavier mass than on a smaller and lighter mass.			X	X			X	X	4
A warm body or object tends to lose its heat to a colder body or object.			X	X					2
All heavenly bodies have an attraction for each other.	X	X	X	X		X	X	X	7
Heavenly bodies are in motion and tend to remain in motion.								X	1
Almost all the energy available on the earth comes from the sun.	X	X	X	X	X		X	X	7

*Table I is read thus: The principle "All bodies in the solar system travel around the sun" was found at least once in each of the textbooks 1, 2, 3, 4, 6, 7, and 8, a total of seven different books, and was assigned to the topic Astronomy under which it was found in the textbooks.

TABLE I

THE NUMBERS OF EIGHTH-GRADE TEXTBOOKS OF GENERAL SCIENCE IN WHICH THE UNDERLYING PRINCIPLES OF PHYSICAL AND BIOLOGICAL SCIENCE WERE FOUND

Principles	Books in which principles occurred							
	1	2	3	4	5	6	7	Total
ASTRONOMY								
*All the bodies in the solar system travel around the sun.	X	X	X	X		X	X	7
The force of gravity is greater on a larger and heavier mass than on a smaller and lighter mass.			X	X			X	3
A warm body or object tends to lose its heat to a colder body or object.			X	X				2
All heavenly bodies have an attraction for each other.	X	X	X	X		X	X	7
Heavenly bodies are in motion and tend to remain in motion.							X	1
Although all the energy available on the earth comes from the sun.	X	X	X	X	X		X	7

*Table I is read thus: The principle "All bodies in the solar system travel around the sun" was found at least once in each of the textbooks 1, 2, 3, 4, 6, 7, and 8, a total of seven different books, and was assigned to the topic Astronomy under which it was found in the textbooks.

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
7 The rotation of the earth causes an apparent rotation of the stars.					X				1
8 The length of time it takes for a planet to travel around the sun depends upon its distance from the sun.	X					X			2
9 It is possible to determine what elements are contained in the sun by studying their color and line schemes through a spectroscope.	X	X	X			X	X	X	6
10 Nearly vertical rays of radiant energy will produce greater heat on a surface than will the more slanted radiant rays.	X		X	X	X	X		X	6
SOUND									
Sound travels through matter.				X		X			2
The motion of any object in the air causes air waves which spread out in all directions.						X			1
Sound travels in waves.						X			1
The faster a body vibrates, the higher is the pitch.				X		X			2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
The rotation of the earth causes an apparent rotation of the stars.					X				1
The length of time it takes for a planet to travel around the sun depends upon its distance from the sun.	X					X			2
It is possible to determine what elements are contained in the sun by studying their color and line schemes through a spectroscope.	X	X	X			X	X	X	6
Nearly vertical rays of radiant energy will produce greater heat on a surface than will the more slanted radiant rays.	X		X	X	X	X		X	6
SOUND									
Sound travels through matter.				X		X			2
The motion of any object in the air causes air waves which spread out in all directions.						X			1
Sound travels in waves.						X			1
The faster a body vibrates, the higher is the pitch.				X		X			2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Sound is produced by vibrating bodies.				X					1
High pitched strings are tighter than lower pitched strings.						X			1
The loudness or intensity of a sound depends upon the amount of air that the sounding body sets in motion.				X		X			2
Sound travels by air particles hitting other air particles.				X					1
LIGHT									
Light rays are bent when they pass from one substance to another substance of different density.				X					1
Dark clothing absorbs more heat than it reflects while light clothing reflects more heat than it absorbs.		X					X		2
When sunlight is passed through a glass prism, the primary colors separate according to their wave lengths.								X	1
Light travels in straight lines.				X	X			X	3

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Sound is produced by vibrating bodies.				X					1
High pitched strings are lighter than lower pitched strings.			X						1
The loudness or intensity of a sound depends upon the amount of air that one sounding body sets in motion.			X	X					2
Sound travels by air particles hitting other air particles.				X					1
LIGHT									
Light rays are bent when they pass from one substance to another of different density.				X					1
Dark clothing absorbs more heat than it reflects while light clothing reflects more heat than it absorbs.		X					X		2
When sunlight is passed through a glass prism, the primary colors separate according to their wave lengths.								X	1
Light travels in straight lines.				X	X			X	3

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
15 Part of the light striking a surface is reflected from the surface.				X	X				2
16 The sun is the earth's main source of natural light.					X			X	2
Images in a plane mirror are erect and reversed.				X					1
17 The intensity of light decreases as the distance from its source increases.					X				1
18 Dark colored surfaces absorb light better than light colored surfaces.					X			X	2
19 Rough or unpolished surfaces absorb light better than smooth or polished surfaces.					X			X	2
Light travels as waves.								X	1
The smoother the surface which light rays strike, the better the reflection.				X					1
The law of reflection states that the angle of incidence equals the angle of reflection.				X					1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Light rays may be bent by reflection and refraction.				X	X				2
The higher the temperature in the filament in a bulb, the greater the quantity of electrical energy is changed to light.					X				1
MATTER, ENERGY AND SIMPLE MACHINES									
Force is required to move matter thus doing work.	X			X	X	X		X	5
Gravity is a force acting at all times; every particle of matter attracts all other particles.	X			X	X	X		X	5
Friction produces heat; no two bodies can be rubbed together without a change of some of the mechanical energy into heat energy.					X	X		X	3
Work is done when a body is moved.					X			X	2
The more energy possessed by a body the greater is its ability to do work.	X			X	X	X			4
Sliding friction is greater or offers more resistance than rolling friction.				X	X	X		X	4

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Light rays may be bent by reflection and refraction.				X	X				3
The bigger the lever is the greater the quantity of electrical energy is changed to light.					X				1
Force is required to move matter thus doing work.	X			X	X	X		X	5
Gravity is a force acting at all times; every particle of matter attracts all other particles.	X			X	X	X		X	5
Friction produces heat; no two bodies can be rubbed together without a change of some of the mechanical energy into heat energy.				X	X			X	3
Work is done when a body is moved.					X			X	2
The more energy possessed by a body the greater is its ability to do work.	X			X	X	X			4
Sliding friction is greater or offers more resistence than rolling friction.				X	X	X		X	4

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
All moving objects and moving materials have energy of motion or kinetic energy.	X								1
The more energy stored due to position the greater the potential energy.	X					X			2
All objects or materials that are not moving have stored or potential energy.	X					X			2
The longer a pendulum the more slowly it swings; the shorter a pendulum the more rapidly it swings.						X		X	2
Objects at rest tend to remain at rest, while objects in motion tend to continue in motion.	X			X	X	X		X	5
The heavier an object, the greater is its inertia.	X								1
In a machine, the product of the force times the distance through which it moves equals the product of the resistance times the distance through which it moves.		X		X	X			X	4

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
A smooth surface offers less resistance to motion than does a rough surface.	X			X	X			X	4
Friction is always encountered whenever work is done.					X			X	2
A body in circular motion tends to fly outward in a straight line making a right angle with the radius of the circle.	X			X				X	3
The amount of work obtained from a machine is never as much as the amount of work put into the machine.					X				1
Two masses of matter cannot occupy the same space at the same time.								X	1
All matter has weight and takes up space.	X							X	2
Matter can be changed in form.	X								1
Every substance is composed of very small particles called molecules.	X								1
All molecules of the same material are identical and attract each other.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
A smooth surface offers less resistance to motion than does a rough surface.	X			X	X			X	4
Friction is always encountered whenever work is done.					X			X	2
A body in circular motion tends to fly outward in a straight line making a right angle with the radius of the circle.	X			X				X	3
The amount of work obtained from a machine is never as much as the amount of work put into the machine.					X				1
Two masses of matter cannot occupy the same space at the same time.								X	1
All matter has weight and takes up space.	X							X	2
Matter can be changed in form.	X								1
Every substance is composed of very small particles called molecules.	X								1
All molecules of the same material are identical and attract each other.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Energy can be changed in form, but cannot be created or destroyed easily by man.	X			X					2
WEATHER AND CLIMATE									
Increasing the pressure on a confined gas, decreases the volume, and reducing the pressure, allows the volume to increase.			X						1
Gases expand when heated and contract when cooled.			X						1
The higher the temperature of the air, the greater is the amount of moisture required to saturate it.	X	X							2
Heat radiates from the ground much more easily into dry than into moist air.							X		1
Ocean temperatures are less variable from time to time in the same place than is the temperature of the land.							X		1
When air is cooled sufficiently, the moisture in it condenses.	X		X		X				3

	Books in which instructions occurred								
Arithmetics	1	2	3	4	5	6	7	8	Total
generally can be changed in form, but cannot be changed so easily as this.	X		X		X				3
MEASURES AND CAPACITY									
Increase the pressure on a confined gas, decreases the volume and raises the temperature of the gas.			X				X		2
Heat increases the volume of a given mass of gas.			X				X		2
Heat increases the volume of gas.	X	X							2
When cooled.			X						1
Increase.			X						1

TABLE I (CONTINUED)

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Air moves from points of greater pressure to points of less pressure causing air currents or winds.	X	X	X			X		X	5
Differences in temperature causes differences in atmospheric pressure and these differences cause winds.	X	X	X					X	4
Whenever air is heated, a given volume of it becomes lighter and is then pushed upward by the greater pressure of the cooler, heavier air around it.	X	X	X			X		X	5
The sun, earth, and earth's motion are closely related to the weather.						X	X	X	3
Solids, liquids, and gases usually expand when heated and contract when cooled.			X						1
The pressure of the wind increases as the square of its velocity.			X						1
The warmer the air the more moisture it can hold; the colder the air the less moisture it can hold.	X		X				X		3

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
30 Heat energy tends to move from a body of higher temperature to a body of lower temperature.			X						1
31 The more slanting the rays of the sun, the less heat the rays supply.			X			X	X		3
32 The temperature of the air of a place is affected by the direction of winds.	X	X	X						3
33 Water has a greater capacity for absorbing heat than any other common substance.			X			X		X	3
34 When water takes up heat, it evaporates to water vapor; and when water vapor cools or loses heat, it condenses to water.						X		X	2
MAGNETISM AND ELECTRICITY									
Atoms are made of three kinds of electrical particles: positive, negative, and neutral.				X					1

				X					1
						X		X	2
			X			X		X	3
	X	X	X						2
			X			X	X		3
			X						1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Upon increasing the resistance in an electrical circuit without changing the voltage or electrical force, a smaller current flows; when the voltage is increased, a larger current flows.					X			X	2
Change the direction of flow of current in a wire and the magnetic field around the wire changes direction.								X	1
When a substance is heated by electricity to a sufficiently high degree of temperature, it glows because a part of the heat energy has been transformed into light energy.					X	X		X	3
All wires carrying an electric current resist the flow of the current; the greater the resistance, the hotter the wire.					X	X		X	3
All wet cells change chemical energy into electrical energy.		X		X	X	X		X	5
Magnets have lines of force about their poles.		X		X				X	3

Boston University
School of Education
Library

Footprints	Books in which footprints occurred								
	1	2	3	4	5	6	7	8	Total
Boyer.		X		X				X	3
Members have time of force spent rustl									
electrical energy.		X		X	X	X		X	5
All new cells consume									
rue normal rue mile.					X	X		X	3
Eleanor rue resistance, rue collège! rue restez rue flow of electric college									
energy.					X	X		X	3
formed fuse light energy rue need plumber or rue post it fuse because a medium of remembering, or a sufficiently pipe depend of electricity upon a substance is									
changes direction.								X	1
light along rue mile mile and rue medium flow of, college is a									
change rue direction of									
a teaspn college light.					X			X	5
voltage is increased, rent light! When rue force, a smaller col- voltage of electrical station current rue electric client									
upon increasing rue resistance in an									

TABLE 1 (CONTINUED)

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
When a magnet is allowed to float freely, it will turn until it points north and south.		X		X		X			3
An electric current may be produced by: (1) rubbing or friction; (2) by chemical action; (3) by the use of magnets.		X		X					2
Unlike electrical charges attract and like electrical charges repel.		X		X	X	X		X	5
EARTH'S SURFACE AND CHANGES									
35 The surface of the earth has been undergoing constant gradual changes from its very beginning.	X				X	X	X	X	5
36 The farther below the surface a stratum of rock lies, the older it is.							X		1
37 Running water, wind, glaciers, and other agencies are constantly moving soil and rocks from higher levels to lower levels.	X						X	X	3
38 The surface of the earth is constantly changing.	X			X	X	X	X	X	6

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
37 Two groups of things are constantly acting on the earth's surface, one building it up and the other tearing it down.					X		X		2
40 All bodies are attracted to the earth by a force called gravity.	X				X				2
41 Rocks are changed in form and shape by the action of heat, water, and pressure.	X					X	X		3
42 The weather appears to repeat itself every twenty-three years.								X	1
43 Only a part of the earth has emerged from the Ice Age.								X	1
44 The number of sun spots on the sun increases at eleven year intervals.								X	1
45 Disturbances at the surface of and in the sun have considerable effect on the earth, especially on sending messages by telephone, telegraph and radio.								X	1
46 Soil is composed of small parts of rocks.	X			X	X			X	4

	Books in which trimethoprim occurred								
Trimethoprim	1	2	3	4	5	6	7	8	Total
two blocks to return one could not find on the shelf, call- ing attention to it and requesting it be found.					X		X		2
All books are searched to the shelf by a force called Circuit.	X				X				2
Books are expected to stay one month (a section of Dead) after which time they are charged to						X	X		2
the member's card. Every month- ly report shows the member's absence from the shelf.								X	1
Card is hard to read when the book is returned.								X	1
Books are charged to the number on the card, not to the member of the family who								X	1
Books are to be returned to the shelf in the order they were charged out	X				X	X		X	4

TABLE I (CONTINUED)

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Fossils give us information about life on earth before present-day life.	X			X	X		X	X	5
Some coasts are rising while others are sinking.	X			X	X	X	X	X	6
A valley goes through three stages of development, youth, maturity, and old age.	X								1
FIRE AND HEAT									
The sun is the earth's most important source of heat.								X	1
A fuel burns only if heated to its kindling temperature in air.					X				1
Heat radiates outward from its source in straight lines and in all directions.	X				X			X	3
Dark colored objects absorb radiant heat faster than light colored objects.	X								1
Whenever two bodies are in contact, the warmer body always gives some of its heat energy to the colder body.	X		X						2
Heat increases the speed of evaporation of liquids.	X								1

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Possible give us information about life on earth before present-day life.	X			X	X		X	X	5
Some cosmic are rising while others are sinking.	X			X	X	X	X	X	6
A valley goes through three stages of development, youth, maturity, and old age.	X								1
FIRE AND HEAT									
The sun is the earth's most important source of heat.								X	1
A lucifer burns only if heated to its kindling temperature in air.					X				1
Heat radiated outward from its source in straight lines and in all directions.	X				X			X	3
Dark colored objects absorb radiant heat faster than light colored objects.	X								1
Whenever two bodies are in contact, the warmer body always gives some of its heat energy to the colder body.	X			X					2
Heat increases the speed of evaporation of liquids.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Most substances can be changed from one state (solid, liquid, or gas) to another by being heated or cooled.	X					X			2
All energy, whether mechanical, electrical, or light, produces heat when it acts on matter.	X				X	X			3
The angle at which the sun's rays strike the earth affects the amount of heat absorbed.								X	1
A certain amount of heat must be in matter before matter can be changed from one state (solid, liquid, or gas) to another.	X				X			X	3
Heat can be transferred from one body to another.	X				X				2
Whenever air is heated, a given volume of it becomes lighter and is then pushed upward by the greater pressure of the cooler, heavier air around it.	X				X				2
Heat is used to destroy bacteria.								X	1
Gases are poor conductors of heat.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
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Most substances can be changed from one state (solid, liquid, or gas) to another by being heated or cooled.	X					X			2
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Heat can be transferred from one body to another.	X				X				2
Whenever air is heated, a given volume of it becomes lighter and is then pushed upward by the greater pressure of the cooler, heavier air around it.	X				X				2
Heat is used to destroy bacteria.								X	1
Germs are poor conductors of heat.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
FLUIDS									
Fluids, when heated, do not lose weight but merely expand in size.	X								1
Fluids (liquids or gases) that are heated are pushed up by the heavier, colder fluids immediately below and to the side of them.	X							X	2
The more the temperature of a liquid is raised, the greater is the amount of a solid that can be dissolved in the liquid.			X					X	3
Dissolving substances in water will raise the boiling point and lower the freezing point.			X					X	2
Increasing the pressure of the water vapor above water in a closed container raises the boiling point of the water.			X					X	2
A body immersed or floating in water or a liquid is buoyed up by a force equal to the weight of the liquid displaced by the body.	X								1

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Water seeks its own level.	X		X						2
At a point in water, or any liquid, the force exerted in every direction by the liquid is the same.	X		X					X	3
The pressure under water becomes greater as the distance below the surface becomes greater.	X		X						2
Heat changes water from a solid state, to a liquid state, to a gaseous state; this is one-half of the water cycle.			X		X			X	3
Air exerts pressure.					X	X			2
Whenever a confined gas is reduced in volume, the pressure it exerts is increased.					X	X		X	3
Air pressure will not balance a column of water more than thirty-three feet high.					X				1
PLANTS AND ANIMALS									
Plants need sunlight, warmth, moisture, good soil, and minerals.							X	X	2

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
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At a point in water, or any liquid, the force exerted in every direction by the liquid is the same.	X		X					X	3
The pressure under water becomes greater as the distance below the surface becomes greater.	X		X						2
Heat changes water from a solid state, to a liquid state, to a gaseous state; this is one-half of the water cycle.			X		X			X	3
Air exerts pressure.					X	X			2
Whenever a confined gas is reduced in volume, the pressure it exerts is increased.					X	X		X	3
Air pressure will not balance a column of water more than thirty-three feet high.					X				1
PLANTS AND ANIMALS									
Plants need sunlight, warmth, moisture, good soil, and minerals.							X	X	2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Usually in order that an ovum may develop, the egg nucleus within it must combine with a sperm nucleus.	X		X			X	X	X	5
Most green plants develop many more seeds than they possibly need to keep their kind on earth if all the seeds grew into plants.		X			X	X	X		4
Only a few of the many seeds that are formed actually grow and produce plants.		X			X	X	X		4
Seeds are adapted so that they may be scattered in different ways.	X	X			X	X	X	X	6
Leaves, with the aid of energy from the sun, make starch from water and carbon dioxide.	X	X				X	X		4
All animals are alike in that they meet changing seasons in some way.		X				X	X		3
The process of losing water takes place much less rapidly in spiny than in leafy plants.							X		1
Man is the most widely adapted living thing.				X	X	X	X	X	5

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Usually in order that an ovum may develop, the egg nucleus within it must combine with a sperm nucleus.	X		X			X	X	X	5
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Man is the most widely adapted living thing.				X	X	X	X	X	5

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Climate and weather influence the health and energy of man more than most other conditions.							X		1
Oxygen must come in contact with digested food before the food's energy can be released.	X						X		2
The human body indirectly changes the energy of the sun into the energy of motion.							X		1
Man needs energy in order to live.					X		X		2
The rate at which energy is released is greatly increased with vigorous exercise.							X		1
All living things are made of small units called cells.	X	X			X	X			4
Man cannot live without food.	X	X				X		X	4
All energy used by plants and animals can be traced to the sun.		X			X				2
All cells of the body use energy.	X	X							2

	Books in which Participles occurred								
Participles	1	2	3	4	5	6	7	8	Total
Diminished and weakened							X		1
Full sense to the word	X	X							2
All sense of rude vigour									
gone.		X			X				2
All energy need not be exerted to the end									
and food.	X	X				X		X	4
Man cannot live with-									
called cells.	X	X			X	X			4
made of small nuts									
All living substance are									
exercise.							X		1
With Aphorisms									
is clearly understood									
energy is referred									
the term is found									
other to live.					X		X		2
Man needs energy in									
wood.							X		1
into the energy of									
energy is the same									
attracts species the									
The human body in-									
energy can be referred.	X						X		2
food which the food's									
consumed with digested									
given most come in									
room.							X		1
and most other condi-									
the energy of man note									
sustenance the result									
Diminished and weakened									

TABLE I (CONTINUED)

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Evaporation of perspiration occurs faster in dry air than in moist air.								X	1
Carbohydrates, fats, and proteins are essential for life.		X					X	X	3
Life exists from the depth of the oceans to the mountain heights.				X		X	X		3
Living things are found everywhere.				X	X	X			3
Parasites live on many kinds of living things.			X	X	X			X	4
Some living things depend upon each other for getting part of what they need in order to live.				X	X	X		X	4
Every kind of living thing, in spite of their enemies, seems to produce enough life to continue its kind on earth.				X	X		X		3
Cells are constantly being destroyed and rebuilt.						X			1

Principles	Books in which principles occur								
	1	2	3	4	5	6	7	8	Total
Responsibility of beneficia- ries to furnish in writing all the facts relevant to the case.								X	1
Corporations' fees' and Florists' tax essential for life.		X					X	X	3
Life exists FLOW AND depend on the measure to the measure				X		X	X		3
Plants contain gas which evaporates necessary.				X	X	X			3
Some living entities have no permanent life or some kind of life- like quality.			X	X	X			X	4
Every kind of life- like entity is for Service help of many ways used in nature.				X	X	X		X	4
Every kind of life- like entity is entitled to the same rights as any other living creature.				X	X		X		3
Cells are conserved and developed under						X			1

TABLE I (CONTINUED)

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
New organisms are produced from some part or parts of an old organism.	X								1
The higher animals protect and care for their young until the latter are able to take care of themselves.	X			X		X			3
Living things are constantly striving with each other for the available supply of food.	X				X			X	3
Living things by their life activities affect the welfare of other living things.				X	X				2
Life comes from life.	X	X			X	X	X		5
All living things need air or oxygen.					X	X			2
Cells are organized in the body in order to carry on division of labor.	X								1
Contagious diseases have a definite number of days from the time germs enter the body and begin to grow until the person shows signs of the disease.	X				X				2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
New organisms are produced from some part or parts of an old organism.	X								1
The higher animals protect and care for their young until the latter are able to take care of themselves.	X			X		X			3
Living things are constantly striving with each other for the available supply of food.	X				X			X	3
Living things by their life activities affect the welfare of other living things.					X	X			2
Life comes from life.	X		X	X	X		X		5
All living things need air or oxygen.				X	X				2
Cells are organized in the body in order to carry on division of labor.	X								1
Contagious diseases have a definite number of days from the time germs enter the body and begin to grow until the person shows signs of the disease.	X				X				2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Bodies of all living things are made up of cells.	X								1
Nature tries to maintain a balance.			X		X				2
87 Man cannot live without water.			X					X	2
88 Living things cannot exist long without water.	X				X	X		X	4
Our food supply would vanish without green 89 plants and sunlight.	X							X	2
Green plants can be killed by preventing 90 their shoots from reaching the sunlight.						X			1
Some diseases are caused by plants or animals living in the human body.						X			1
Decay is usually 91 caused by bacteria, molds, and mildews.			X			X			2
MISCELLANEOUS*									
Air pressure decreases 97 the higher we go.	X		X						2

*These principles, all physical science, were not found under any of the preceding topics or units used in this table.

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
93 Heat travels by conduction, convection, and radiation.			X						1
When a gas expands, it takes in heat; when a gas contracts, it gives off heat.			X						1
The greater the pull of 94 the earth's gravity on a body, the greater is the weight of that body.	X			X					2
Friction and inertia 95 must be overcome to move one surface over another.				X					1
Heat causes molecules 96 to move rapidly thus causing heated gases to expand.				X					1
97 Friction produces heat.				X					1
Objects in fluids are 98 buoyed up by the fluid.				X					1
The pressure of rapidly flowing air is less than that of still air.				X					1
99 Energy is needed to do work.		X				X			2
Regardless of size, objects fall to the ground in the same length of time.	X					X			2

TABLE I (CONTINUED)

Principles	Books in which principles occurred								
	I	S	G	Φ	O	C	Y	B	Total
Heat travels by conduction, convection, and radiation.			X						1
When a gas expands, it takes in heat; when a gas contracts, it gives off heat.			X						1
The greater the pull of the earth's gravity on a body, the greater is the weight of that body.	X			X					2
Friction and inertia must be overcome to move one surface over another.				X					1
Heat causes molecules to move rapidly -- thus causing bodies to expand.				X					1
Friction produces heat.				X					1
Objects in fluids are buoyed up by the fluid.				X					1
The pressure of rapidly flowing air is less than that of still air.				X					1
Energy is needed to do work.		X			X				2
Regardless of size, objects fall to the ground in the same length of time.	X				X				2

TABLE I (CONCLUDED)

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Heavier objects have a stronger attraction for each other than do lighter objects.						X			1
Cloth fibers are poor conductors of heat.						X			1
A large amount of heat is required to evaporate a small amount of water.						X			1
Heat loss is prevented by the use of insulators.			X			X			2
The pressure of water at any point below its surface is always equal to the weight of the water and air above that point.	X								1
Water passing rapidly through pipes exerts less pressure than water standing still.	X								1
The closer the centers of two bodies are together, the harder they pull on each other.	X								1

Findings Table I. One hundred and eighty-six principles of science, most of which are parts of a more comprehensive principle or broad generalization, appear in the eight textbooks analyzed. Of the twenty principles appearing in a

Principles	Books in which principles occurred								
	1	2	3	4	5	6	7	8	Total
Heavier objects have a stronger attraction for each other than do lighter objects.						X			1
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Water passing rapidly through pipes exerts less pressure than water standing still.	X								1
The closer the centers of two bodies are together, the harder they pull on each other.	X								1

Finding Tools 1. One hundred and eighty-six principles or natures, most of which are parts of a more comprehensive principle or broad generalization, appear in the eight textbooks analyzed. Of the twenty principles appearing in a

majority of the textbooks analyzed, sixteen are physical science principles and only four are biological principles. Physical science is therefore emphasized at the eighth-grade level almost to the exclusion of biological science. Following the topics or units listed are the numbers of different principles or parts of principles found in a majority of the textbooks analyzed: Astronomy, 5; Matter, Energy, and Simple Machines, 3; Weather and Climate, 2; Magnetism and Electricity, 2; Earth's Surface and Changes, 4; and Plants and Animals, 4. None of the principles are included in all eight textbooks. This table glaringly points out the fact that authors of general science textbooks for use in the eighth grade have reached comparatively little agreement on the principles of science to be taught in the eight-grade course of general science.

Table II which follows shows the number of physical science and biological science principles which were determined for each of the eight textbooks of general science which were analyzed for this investigation. Also included in the table is the relative percent of the number of physical science and biological science principles found in the textbooks.

TABLE II

TOTAL NUMBER OF DIFFERENT PRINCIPLES IN THE FIELDS OF PHYSICAL SCIENCE AND BIOLOGICAL SCIENCE AS FOUND IN EACH TEXTBOOK

Field of Science	Principles in Book								Principles	
	1	2	3	4	5	6	7	8	Number	Percent
*Physical Science	59	17	32	43	45	45	19	61	144	78
Biological Science	16	11	5	8	18	20	18	13	42	22
Total	75	28	37	51	63	65	37	74	186	100

*Table II is read thus: Book 1 contained 59 of a total of 144 physical science principles and 16 of a total of 42 biological science principles, etc. One hundred and forty-four or 78 percent of the 186 different principles were principles of physical science.

Indent 5 spaces

Findings Table II. Table II clearly illustrates the degree of emphasis placed on the fields of physical science and of biological science in each of the textbooks. The eight textbooks yielded a total of one hundred and eighty-six different principles of which one hundred and forty-four or seventy-eight percent were principles of physical science, and forty-two or twenty-two percent were biological principles. Every one of the textbooks contained a greater number of principles of the physical sciences than of the biological sciences.

Table III shows the number of different principles by topics found in eight eighth-grade textbooks of general science.

TABLE III

NUMBER OF DIFFERENT PRINCIPLES BY TOPICS
FOUND IN EIGHT EIGHTH-GRADE TEXTBOOKS OF GENERAL SCIENCE

Topic	Total Number of Different Principles	Book Number								Average Number of Principles Per Book
		1	2	3	4	5	6	7	8	
*Astronomy	10	6	4	7	6	3	5	5	7	5.3
Sound	8	-	-	-	5	-	6	-	-	1.3
Light	15	-	1	-	7	8	-	1	6	2.8
Matter, Energy and Simple Machines	23	15	1	-	9	11	9	-	13	7.2
Weather and Climate	18	7	5	13	-	1	6	5	6	5.3
Magnetism and Electricity	10	-	5	-	6	5	5	-	7	3.5
Earth's Surface and Changes	15	9	-	-	4	7	4	8	10	5.2
Fire and Heat	14	10	-	1	-	6	2	-	5	3.0
Fluids	13	6	-	7	-	4	2	-	7	3.3
Plants and Animals	42	16	11	5	8	18	20	18	13	13.6
Miscellaneous	18	6	1	4	6	-	6	-	-	2.8
Total	186	75	28	37	51	63	65	37	74	53.3

*Table III is read thus: Of the total number of different principles of Astronomy, 10, Book 1 contained 6, Book 2 contained 4, etc., and the average number of principles for the eight textbooks was 5.3.

Findings Table III. Table III clearly indicates the lack of agreement between the writers of the eight general science textbooks employed in relation to the number of principles which

should be included in the various topics of general science at the eighth-grade level. The relationship between the actual total number of principles determined after analyzing the eight books and the total number of principles found per book presents little or no correlation. A situation existed also, whereby even though certain topics were included in some of the textbooks, there were no principles assigned to the books through the use of the criteria established.

Table IV which follows shows the total number of principles determined after analyzing the eight textbooks of general science and the number of principles which were found in each of the eight books. Also included is the relative percent per textbook of the total number of principles found after analyzation of the eight textbooks.

TABLE IV

TOTAL NUMBER OF DIFFERENT PRINCIPLES FOUND IN EIGHT EIGHTH-GRADE TEXTBOOKS OF GENERAL SCIENCE AND NUMBER AND PERCENTAGE OF THE TOTAL FOUND IN EACH BOOK

Total Number of Different Principles	Number of Different Principles in Book								Average
	1	2	3	4	5	6	7	8	
*186	75	28	37	51	63	65	37	74	53
Percent of	40	15	19	27	33	34	19	39	28

*Table IV is read thus: Of the total number of 186 different principles found in all eight books, 75 or 40 percent were found in Book 1, 28 or 15 percent in Book 2, etc., for an average of 53 different principles per book, or an average of 28 percent of the total 186 principles.

Indent 5 spaces

Findings Table IV. Table IV indicates that although Book 1 and Book 8 have an almost identical number of different principles which, even though high when compared to the remaining six books, still are far below the total number of different principles which were included in the textbooks of general science at the eighth-grade level. An average of 53 different principles were determined per book with an average percent of 28 when compared with the 186 different principles found. The average percent of principles found in the textbooks ranged from a low of 15 to a high of 40.

Table V, which follows, shows the total various topics included in the eight books of general science analyzed for this investigation and the individual books wherein these topics were found.

TABLE IV

TOTAL NUMBER OF DIFFERENT PRINCIPLES FOUND IN EIGHT-GRADE TEXTBOOKS OF GENERAL SCIENCE AND NUMBER AND PERCENTAGE OF THE TOTAL FOUND IN EACH BOOK

Total Number of Different Principles	Number of Different Principles in Book							Average
	1	2	3	4	5	6	7	8
*186	75	88	87	81	85	83	87	84
Percent of	40	15	19	27	33	34	19	28

*Table IV is read thus: Of the total number of 186 different principles found in all eight books, 75 or 40 percent were found in Book 1, 28 or 15 percent in Book 2, etc., for an average of 84 different principles per book, or an average of 28 percent of the total 186 principles.

Principle Table IV. Table IV indicates that although Book 1 and Book 8 have an almost identical number of different principles which, even though high when compared to the remaining six books, still are far below the total number of different principles which were included in the textbooks of general science at the eighth-grade level. An average of 84 different principles were determined per book with an average percent of 28 when compared with the 186 different principles found. The average percent of principles found in the textbooks ranged from a low of 15 to a high of 40.

Table V, which follows, shows the total various topics included in the eight books of general science analyzed for this investigation and the individual books wherein these topics were found.

TABLE V

NUMBER OF DIFFERENT TEXTBOOKS OF GENERAL SCIENCE IN WHICH MAJOR SUBJECT-MATTER TOPICS APPEARED

Topic	Book Number								Total
	1	2	3	4	5	6	7	8	
*Astronomy	X	X	X	X	X	X	X	X	8
Sound and Light				X	X	X		X	4
Matter, Energy and Simple Machines	X	X		X	X	X		X	6
Weather and Climate	X	X	X		X	X	X	X	7
Magnetism and Electricity		X		X	X	X		X	5
Earth's Surface and Changes	X			X	X	X	X	X	6
Fire and Heat	X				X	X		X	4
Fluids	X		X		X	X		X	5
Plants and Animals	X	X	X	X	X	X	X	X	8
Miscellaneous	X	X	X		X	X	X		6

*Table V is read thus: The topic Astronomy was found in Book 1, Book 2, Book 3, etc., for a total of eight books showing that all books contained the topic of Astronomy.

Findings Table V. Table V shows the following: The topics of the eight eighth-grade general science books were found to be present to the following extent: Astronomy in eight books;

Topic	Book Number								Total
	1	2	3	4	5	6	7	8	
Arithmetic	X	X	X		X	X	X		6
Algebra	X		X		X	X		X	5
Plane Geometry	X				X	X		X	4
Solid Geometry and Trigonometry	X			X	X	X	X	X	6
Physics		X		X	X	X		X	5
Chemistry	X	X	X		X	X	X	X	7
Elementary Science and Nature Study	X	X		X	X	X		X	6
Bodily Welfare				X	X	X		X	4
*Physiology	X	X	X	X	X	X	X	X	8
Total	6	4	4	5	8	8	4	7	

TABLE V

NUMBER OF DIFFERENT TEXTBOOKS TO BE PURCHASED
IN EACH HIGH SCHOOL GIVING FOUR-YEAR COURSES

Sound and Light in four books; Matter, Energy and Simple Machines in six books; Weather and Climate in seven books; Magnetism and Electricity in five books; Earth's Surface and Changes in six books; Fire and Heat in four books; Fluids in five books; and Plants and Animals in eight books.

SUMMARY OF FINDINGS

The investigation revealed that a total of one hundred and eighty-six principles of physical science and biological science were determined upon analyzing the eight textbooks of general science used for this study. Of this total number one hundred and forty-four were physical science principles while the remainder, forty-two, were biological science principles. Twenty principles (sixteen physical science principles and four biological science principles) appeared in a majority of the textbooks analyzed. Following the topics or units listed are the number of different principles found in a majority of the textbooks analyzed: Astronomy, 5; Matter, Energy and Simple Machines, 3; Weather and Climate, 2; Magnetism and Electricity, 2; Earth's Surface and Changes, 4; and Plants and Animals, 4.

Book I contained seventy-five principles or forty percent of the total number of one hundred and eighty-six principles determined. This represented the largest total of the eight textbooks analyzed. The lowest number of principles, twenty-eight or fifteen percent of the total number of

principles, was determined for Book II. The average number of principles determined for all eight textbooks was fifty-three principles for an average of twenty-eight percent of the total number of principles determined for all eight textbooks.

The topics of the eight eighth-grade general science books were found to be present to the following extent: Astronomy in eight books; Sound and Light in four books; Matter, Energy and Simple Machines in six books; Weather and Climate in seven books; Magnetism and Electricity in five books; Earth's Surface and Changes in six books; Fire and Heat in four books; Fluids in five books; and Plants and Animals in eight books.

CHAPTER III

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

RESTATEMENT OF THE PROBLEM

The problem of this investigation is to determine the principles of the physical and biological sciences found in eight textbooks of general science for grade eight.

SUMMARY OF TECHNIQUES EMPLOYED

This investigation was conducted after selecting eight textbooks which conformed to the criteria of textbook selection as established by the investigator and approved by the Seminar in Science Education at Boston University. The books were then analyzed for principles and those statements which conformed to the criteria of a principle were chosen. The principles were then reviewed by a specialist in the field of the teaching of science. This specialist checked them for conformance to the criteria established and for technical accuracy of statement at the eighth-grade level of comprehension. Any statements of principles judged by him as not conforming to the criteria and which he could not reword to conform were deleted from the final list of principles. Furthermore, if the specialist thought that the language in a statement of a principle was not suitable

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for the eighth-grade level of comprehension, he reworded the principle to make it comprehensible at that level. Thus, the statements of the principles were properly validated. The opinion of the specialist was the opinion adhered to by the investigator. Some of the principles were restated and others were deleted. Then followed a random sampling of 100 pages for reanalyzation to determine the coefficient of reliability for the selection of principles from textbooks. This coefficient of reliability was determined to be 0.86.

SUMMARY OF THE FINDINGS

The investigation revealed that a total of one hundred and eighty-six principles of physical science and biological science were determined upon analyzing the eight textbooks used. Of this total one hundred and forty-four principles or seventy percent were physical science principles while, the remainder, forty-two principles or twenty-two percent were biological science principles. Only sixteen physical science principles and only four biological science principles of the total of one hundred and eighty-six principles found were contained in a majority of the textbooks. Following are the number of different principles under the topics in which they were found in a majority of the textbooks:

Astronomy 5; Matter, Energy and Simple Machines 3; Weather and Climate 2; Magnetism and Electricity 2; Earth's Surface and Changes 4; and Plants and Animals 4.

Book I had seventy-five or forty percent of the total number of one hundred and eighty-six principles found in the eight textbooks of general science analyzed. Book II contained the smallest number, having twenty-eight principles or fifteen percent of the total number. The average number of different principles for the eight textbooks was fifty-three principles for an average of twenty-eight percent.

All textbooks included principles under Astronomy, and Plants and Animals. Principles for the other topics were present to the following extent: Sound in two books; Light in five books; Matter, Energy and Simple Machines in six books; Weather and Climate in seven books; Magnetism and Electricity in five books; Earth's Surface and Changes in six books; Fire and Heat in five books; and Fluids in five books.

The authors of the eight books agreed unanimously that two topics or units, Astronomy, and Plants and Animals, should be incorporated in textbooks of general science for the eight-grade level. For the remaining topics, the following was found to be true: the topic, Weather and Climate, was found in seven textbooks; the topics Matter, Energy and Simple Machines, and Earth's Surface and Changes were found

in six books; the topics Magnetism and Electricity, and Fluids, were found in five books; and the topic Fire and Heat was found in four books.

CONCLUSIONS

This study revealed that even though one hundred and eighty-six different principles were found in the eight books of general science analyzed, many of these principles were only implied and not stated definitely as principles.

The wide range in the number and nature of the different principles used in each book shows that there is lack of agreement among authors as to how many and which principles should be incorporated in the textbooks of general science for the eight-grade level. This is not in agreement with the objectives of the Thirty-First Yearbook.

It was unanimously agreed by the authors of the eight textbooks analyzed that the major emphasis at the eighth-grade level is to be placed upon the physical science principles rather than the biological science principles.

In the analysis of the same eight textbooks for topics or units, it was apparent that here, also, little uniformity existed in relation to the major subject-matter topics or units to be studied in general science at the eight-grade level.

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In the analysis of the same eight textbooks for topics or units, it was apparent that here, also, little uniformity existed in relation to the major subject-matter topics or units to be studied in General science at the eight-grade level.

RECOMMENDATIONS

It is recommended that the seventh-grade textbooks of general science be analyzed for principles and that the principles so found be written in a language appropriate to the seventh-grade level. This, then, would complete the analysis of the general science textbooks at the junior-high-school level for principles, and would definitely lay the groundwork for subsequent research leading to further standardization of a list of important scientific principles, a functional understanding of which should be developed to a marked degree at definite grade levels in general science courses.

The principles of general science should be stated so that they would be easily understood by the pupils at the grade level for which intended. This last fact should be recognized by future authors of general science textbooks of the junior-high-school grades if teachers are to be expected to make any progress at all in teaching science through the medium of scientific principles.

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